

IN THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application.

Claim 1 (Previously Presented): A magnetoresistance effect element comprising:

a magnetoresistance effect film including a magnetization fixed layer having a ferromagnetic film in which the direction of magnetization is substantially fixed to one direction, a magnetization free layer having a ferromagnetic film in which the direction of magnetization varies in response to an external magnetic field, and a non-magnetic intermediate layer provided between the magnetization fixed layer and the magnetization free layer, the non-magnetic intermediate layer comprising a non-magnetic metallic layer and a resistance regulating layer stacked on the non-magnetic metallic layer, the resistance regulating layer formed in the non-magnetic intermediate layer or on the interface between the non-magnetic intermediate layer and at least one of the magnetization fixed layer and the magnetization free layer; and

a pair of electrodes which are electrically connected to the magnetoresistance effect film for applying a current in a direction perpendicular to the plane of the magnetoresistance effect film,

the resistance regulating layer containing an oxide, a nitride, a fluoride, a carbide or a boride as a principal component and including holes of a metal phase of 2% to 30%, and

the mean diameter of each of the holes of the resistance regulating layer being in the range from 10% to 100% with respect to the total thickness of the magnetization free layer, the non-magnetic intermediate layer and the magnetization fixed layer.

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Claim 2 (Previously Presented): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer restricts the quantity of a sense current passing through the magnetoresistance effect film.

Claim 3 (Previously Presented): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer has the holes at a rate of hole area which is 50 % or less.

Claim 4 (Original): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer is made of two kinds or more of metallic elements.

Claim 5 (Original): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer is formed in the magnetization free layer, or on the magnetization free layer on the opposite side to the non-magnetic intermediate layer.

Claim 6 (Canceled).

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Claim 7 (Original): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer is formed in the magnetization fixed layer, or on the magnetization fixed layer on the opposite side to the non-magnetic intermediate layer.

Claim 8 (Previously Presented): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer contains, as a principal component, at least one of oxides, nitrides, fluorides, carbides or borides of an element selected from the group

consisting of B, Si, Ge, Ta, W, Nb, Al, Mo, P, V, As, Sb, Zr, Ti, Zn, Pb, Th, Be, Cd, Sc, La, Y, Pr, Cr, Sn, Ga, Cu, In, Rh, Pd, Mg, Li, Ba, Ca, Sr, Mn, Fe, Co, Ni and Rb.

Claim 9 (Original): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer is formed on the magnetization free layer on the opposite side to the non-magnetic intermediate layer, or in the non-magnetic intermediate layer, or on the interface of the non-magnetic intermediate layer, and contains a metal including at least one of Cu, Au, Ag, Ru, Ir, Re, Rh, Pt, Pd, Al and Os.

Claim 10 (Original): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer comprises:

a first region which is formed on the magnetization free layer on the opposite side to the non-magnetic intermediate layer, or in the non-magnetic intermediate layer, or on the interface of the non-magnetic intermediate layer, and which contains Cu as a principal component; and

a second region which contains, as a principal component, at least one of oxides, nitrides, fluorides, carbides and borides of an element selected from the group consisting of B, Fe, Mo, Pb, Ta, Cr, V, Si, Sb and Ge.

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Claim 11 (Previously Presented): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer comprises:

a first region which is formed on the magnetization free layer on the opposite side to the non-magnetic intermediate layer, or in the non-magnetic intermediate layer, or on the

interface of the non-magnetic intermediate layer, and which contains Au as a principal component; and

a second region which contains, as a principal component, at least one of oxides, nitrides, fluorides, carbides and borides of an element selected from the group consisting of B, Fe, Ge, Mo, P, Rh, Si, W and Cr.

Claim 12 (Original): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer comprises:

a first region which is formed on the magnetization free layer on the opposite side to the non-magnetic intermediate layer, or in the non-magnetic intermediate layer, or on the interface of the non-magnetic intermediate layer, and which contains Ag as a principal component; and

a second region which contains, as a principal component, at least one of oxides, nitrides, fluorides, carbides and borides of an element selected from the group consisting of Be, Co, Cr, Fe, Mo, Pb, Si, Ta, V, W, Ge, Sn, Al and Rh.

Claim 13 (Canceled).

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Claim 14 (Original): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer has a thickness of 0.5 to 5 nm.

Claim 15 (Original): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer includes holes of a metal phase of 2 % to 30 %.

Claim 16 (Original): A magnetoresistance effect element as set forth in claim 15, wherein the mean diameter of each of the holes of the resistance regulating layer is in the range of from 5 % to 100 % with respect to the total thickness of the magnetization free layer, the non-magnetic intermediate layer and the magnetization fixed layer.

Claim 17 (Original): A magnetoresistance effect element as set forth in claim 15, wherein the distance between adjacent two of the holes of the metal phase is in the range of from 10 nm to 100 nm.

Claim 18 (Original): A magnetoresistance effect element as set forth in claim 15, wherein the mean distance between adjacent two of the holes of the metal phase is in the range of from 10 nm to 100 nm.

Claim 19 (Previously Presented): A magnetic head having a magnetoresistance effect element as set forth in any one of claims 1-5, 7-12, and 14-17.

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Claim 20 (Original): A magnetic recording and/or reproducing system which has a magnetic head as set forth in claim 19 and which is capable of reading magnetic information stored in a magnetic recording medium.

Claim 21 (Previously Presented): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer is formed in the non-magnetic intermediate layer, and contains a metal including at least one of Cu, Au, Ag, Ru, Ir, Re, Rh, Pt, Pd, Al and Os.

Claim 22 (Previously Presented): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer is formed of an insulating material which has the holes, and an electric conduction of the resistance regulating layer is regulated by the holes.

Claim 23 (Previously Presented): A magnetoresistance effect element as set forth in claim 2, wherein the resistance regulating layer contains, as a principal component at least one of oxides, nitrides, fluorides, carbides or borides of an element selected from the group consisting of B, Si, Ge, Ta, W, Nb, Al, Mo, P, V, As, Sb, Zr, Ti, Zn, Pb, Th, Be, Cd, Sc, La, Y, Pr, Cr, Sn, Ga, Cu, In, Rh, Pd, Mg, Li, Ba, Ca, Sr, Mn, Fe, Co, Ni and Rb.

Claim 24 (Canceled).

Claim 25 (Canceled).

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Claim 26 (Previously Presented): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer includes the holes in the oxide, the nitride, the fluoride, the carbide, or the boride, the holes containing an element of the same kind in the oxide, the nitride, the fluoride, the carbide, or the boride.

Claim 27 (Previously Presented): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer includes the holes in the oxide, the nitride, the fluoride, the carbide, or the boride, the holes containing an element of different kind of the oxide, the nitride, the fluoride, the carbide, or the boride.

Claim 28 (Previously Presented): A magnetoresistance effect element as set forth in claim 2, wherein the resistance regulating layer includes the holes in the oxide, the nitride, the fluoride, the carbide, or the boride, the holes containing an element of the same kind in the oxide, the nitride, the fluoride, the carbide, or the boride.

Claim 29 (Previously Presented): A magnetoresistance effect element as set forth in claim 2, wherein the resistance regulating layer includes the holes in the oxide, the nitride, the fluoride, the carbide, or the boride, the holes containing an element of different kind in the oxide, the nitride, the fluoride, the carbide, or the boride.

Claim 30 (Previously Presented): A magnetoresistance effect element as set forth in claim 1, wherein the resistance regulating layer comprises the holes in the oxide, the nitride, the fluoride, the carbide, or the boride, and

two adjacent layers contacting the resistance regulating layer have an electric conduction through the holes of the resistance regulating layer.

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Claim 31 (Previously Presented): A magnetoresistance effect element as set forth in claim 2, wherein the resistance regulating layer comprises the holes in the oxide, the nitride, the fluoride, the carbide, or the boride, and

two adjacent layers contacting the resistance regulating layer have an electric conduction through the holes of the resistance regulating layer.

Claim 32 (Previously Presented): A magnetoresistance effect element comprising:

a magnetoresistance effect film including a magnetization fixed layer having a ferromagnetic film in which the direction of magnetization is substantially fixed to one direction, a magnetization free layer having a ferromagnetic film in which the direction of magnetization varies in response to an external magnetic field, and a non-magnetic intermediate layer provided between the magnetization fixed layer and the magnetization free layer, the non-magnetic intermediate layer comprising a non-magnetic metallic layer and a resistance regulating layer stacked on the non-magnetic metallic layer, the resistance regulating layer formed in the non-magnetic intermediate layer or on the interface between the non-magnetic intermediate layer and at least one layer of the magnetization fixed layer and the magnetization free layer, and

a pair of electrodes which are electrically connected to the magnetoresistance effect film for applying a current in a direction perpendicular to the plane of the magnetoresistance effect film,

the resistance regulating layer containing an oxide, a nitride, a fluoride, a carbide or a boride as a principal component and including holes, and

the magnetoresistance effect element sensing a relative angle between the magnetization direction of the magnetization fixed layer and the magnetization direction of the magnetization free layer by a change of current passing through the holes.

Claim 33 (Previously Presented): A magnetoresistance effect element comprising;  
a magnetoresistance effect film including a magnetization fixed layer having a ferromagnetic film in which the direction of magnetization is substantially fixed to one direction, a magnetization free layer having a ferromagnetic film in which the direction of magnetization varies in response to an external magnetic field, and a non-magnetic



intermediate layer provided between the magnetization fixed layer and the magnetization free layer, the non-magnetic intermediate layer comprising a non-magnetic metallic layer and a resistance relating layer stacked on the non-magnetic metallic layer, the resistance regulating layer formed in the non-magnetic intermediate layer or on the interface between the non-magnetic intermediate layer and at least one of the magnetization fixed layer and the magnetization free layer; and

a pair of electrodes which are electrically connected to the magnetoresistance effect film for applying a current in a direction perpendicular to the plane of the magnetoresistance effect film,

the resistance regulating layer containing an oxide, a nitride, a fluoride, a carbide or a boride as a principal component and having a pin holes at a rate of hole area which is 50% or less, and

two adjacent layers which contact the resistance regulating layer having an electric conduction substantially limited to conduction through the pin holes of the resistance regulating layer.

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Claim 34 (Previously Presented): A magnetoresistance effect element as set forth in claim 33, wherein the resistance regulating layer is made of two kinds or more of metallic elements.

Claim 35 (Previously Presented): A magnetoresistance effect element as set forth in claim 33, wherein the resistance regulating layer contains, as a principal component, at least one of oxides, nitrides, fluorides, carbides or borides of an element selected from the group

consisting of B, Si, Ge, Ta, W, Nb, Al, Mo, P, V, As, Sb, Zr, Ti, Zn, Pb, Th, Be, Cd, Sc, La, Y, Pr, Cr, Sn, Ga, Cu, In, Rh, Pd, Mg, Li, Ba, Ca, Sr, Mn, Fe, Co, Ni and Rb.

Claim 36 (Previously Presented): A magnetoresistance effect element as set forth in claim 33, wherein the resistance regulating layer is formed of an insulating material which has pin holes.

Claim 37 (Previously Presented): A magnetoresistance effect element as set forth in claim 33, wherein the pin holes are provided with metal therein.

Claim 38 (Previously Presented): A magnetoresistance effect element as set forth in claim 33, wherein the resistance regulating layer is formed of a first material which is relatively easy to be oxidized and a second material which is difficult to be oxidized, and pin holes are formed of the second material.

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Claim 39 (Previously Presented): A magnetoresistance effect element comprising:  
a magnetoresistance effect film including a magnetization fixed layer having a ferromagnetic film in which the direction of magnetization is substantially fixed to one direction, a magnetization free layer having a ferromagnetic film in which the direction of magnetization varies in response to an external magnetic field, and a non-magnetic intermediate layer provided between the magnetization fixed layer and the magnetization free layer, the non-magnetic intermediate layer comprising a non-magnetic metallic layer and a resistance regulating layer stacked on the non-magnetic metallic layer, the resistance regulating layer formed in the non-magnetic intermediate layer or on the interface between

the non-magnetic intermediate layer and at least one of the magnetization fixed layer and the magnetization free layer; and

a pair of electrodes which are electrically connected to the magnetoresistance effect film for applying a current in a direction perpendicular to the plane of the magnetoresistance effect film,

the resistance regulating layer containing an oxide, a nitride, a fluoride, a carbide or a boride as a principal component and having a pin holes at a rate of hole area which is 50% or less, and

at least 10 pin holes being formed in the resistance regulating layer.

Claim 40 (Currently Amended): A magnetoresistance effect element as set forth in claim 39, wherein the resistance regulating layer is made of two ~~finds~~ kinds or more of metallic elements.

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Claim 41 (Previously Presented): A magnetoresistance effect element as set forth in claim 39, wherein the resistance regulating layer contains, as a principal component, at least one of oxides, nitrides, fluorides, carbides or borides of an element selected from the group consisting of B, Si, Ge, Ta, W, Nb, Al, Mo, P, V, As, Sb Zr, Ti, Zn, Pb, Th, Be, Cd, Sc, La, Y, Pr, Cr, Sn, Ga, Cu, In, Rh, Pd, Mg, Li, Ba, Ca, Sr, Mn, Fe, Co, Ni and Rb,

Claim 42 (Previously Presented): A magnetoresistance effect element as set forth in claim 39, wherein the resistance regulating layer is formed of an insulating material which has pin holes.

Claim 43 (Previously Presented): A magnetoresistance effect element as set forth in claim 39, wherein the pin holes are provided with metal therein.

Claim 44 (Previously Presented): A magnetoresistance effect element as set forth in claim 39, wherein the resistance regulating layer is formed of a first material which is relatively easy to be oxidized and a second material which is difficult to be oxidized, wherein pin holes are formed of the second material.

